2.0 WELL INSTALLATION

The following sections present specific information related to the placement, construction, and development of five extraction wells and five triple-completion monitoring wells near the southern end of the Muscoy Plume OU, and one triple-completion monitoring well in the north-central port of the OU (Figure 2-1). Well construction logs, including lithologic and geophysical information, are presented in Attachment A. Final well inspection forms are presented in Attachment B.

2.1 EXTRACTION WELLS

2.1.1 Extraction Well Locations

The five groundwater extraction wells (EW-108 through EW-112) were placed in an east-west line, north of Baseline Street, in the southern portion of the Muscoy Plume OU. These wells are intended to create a hydraulic barrier to downgradient contaminant migration, thereby protecting uncontaminated portions of the aquifer by removing contaminant mass for the eventual restoration of the aquifer. The *Muscoy Plume Front Extraction Well Technical Memorandum No. 2* (URS, 1998) describes the methods that were used to design the extraction system with the optimum number, pumping rate, and location of wells.

2.1.2 Extraction Well Construction

Drilling Methods. The five extraction wells and their associated piezometers were installed between May 2001 and December 2004 using a combination of a large-diameter bucket auger and reverse-circulation mud rotary techniques. Borehole drilling and well installation were performed by Layne Christensen Company, retained by the SBMWD.

Permanent conductor casings were installed at each extraction well location with a large-diameter bucket auger to about 60 feet below ground surface (bgs), and temporary conductor casings were placed to about 20 feet bgs at the piezometer cluster locations for EW-110 and EW-111. Conductor casings were used to stabilize subsurface formation material and to assist in creating a closed drilling fluid circulation system, reducing the possibility of drilling fluid loss into poorly consolidated or unconsolidated formation material at shallow depths.

Borehole diameters varied by location and depth. Table 2-1 presents the borehole dimensions for the extraction wells and associated piezometers. Each borehole was completed to a depth of 10 to 20 feet greater than the proposed well screen to allow for borehole caving during casing installation.

A URS geologist recorded lithologic information from the drill rig's discharge line as each borehole was drilled. Recorded information includes grain size and shape, grading, mineralogy, United Soil Classification System designation, and other observations. Lithologic samples were collected from the discharge line at approximately 20-foot intervals. Lithologic logs for all locations are presented in Attachment A.

A suite of geophysical logs was collected from each borehole by a subcontractor retained by SBMWD. These logs are presented in Attachment A.

TABLE 2-1

Borehole Dimensions

Borehole Diameter (inches)	Depth Intervals (ft bgs)												
	EW-108	EW-109	EW-110	EW-110PZ	EW-111	EW-111PZ	EW-112	MW-135	MW-136	MW-137	MW-138	MW-139	MW-140
48	0–760						0–800						
38		0–715											
36			0–897		0–1,505								
30	760–1,020						800–937						
28		715–870											
17.5		870–930		0–517									
14.5								0–880	0–760	0–820	0–990	0–570	0-551
13.25						0–485							
10.5									760–930	820–912	990–1,000	570–855	551-865
Total Depth (ft bgs)	1,020	930	897	517	1,505	485	937	880	930	912	1,000	855	865

bgs = below ground surface
ft = feet

TABLE 2-2

Extraction Well Construction Details

Well	Location	Casing Elevation (ft above msl)	Casing Diameter (inches)	Screened Interval (ft bgs)	Screen Slot Size (inches)	Gravel Fill Pipe Depths (ft bgs)	Camera Tube Depth (ft bgs)	Total Well Depth
EW-108	Northwest corner of 13th Street and G Street	1,119.26	20	510–590 670–1,000	0.07	310 510	NA	1,010
EW-108PA		1,119.26	4	370–390	0.02			390
EW-108PB		1,119.26	4	740–760	0.02			760
EW-109	North side of House Street between Perris Street and Herris Street	1,137.05	20	260–330 420–500 550–610 710–840	0.08	260 420 710	405	860
EW-109PZA		1,137.05	4	310–330	0.02			330
EW-109PZB		1,137.05	4	430–450	0.02			450
EW-109PZC		1,137.05	4	800–820	0.02			820
EW-110	East side of Garner Street, approximately 400 feet south of 14th Street	1,149.30	20	225–270 305–650 715–855	0.08	305 710	359.5	865
EW-110PZA		1,145.50	3	193.5–243.5	0.02			243.5
EW-110PZB		1,145.48	3	301.5–321.5	0.02			321.5
EW-110PZC		1,145.49	3	411.5–431.5	0.02			431.5
EW-110PZD		1,145.51	3	491.5–511.5	0.02			511.5
EW-110PZE		1,149.30	4	830–850	0.02			850

TABLE 2-2 (Continued)

Well	Location	Casing Elevation (ft above msl)	Casing Diameter (inches)	Screened Interval (ft bgs)	Screen Slot Size (inches)	Gravel Fill Pipe Depths (ft bgs)	Camera Tube Depth (ft bgs)	Total Well Depth
EW-111	Southwest corner of Pico Street and 14th Street	1,169.51	20	235–265 305–665 765–1,250	0.08	305 765	410	1,260
EW-111PZB		1,165.69	3	375.5–395.5	0.02			395.5
EW-111PZC		1,165.70	3	456–476	0.02			476
EW-111PZD		1,169.49	4	780–800	0.02			800
EW-112	North side of Virginia Street, approximately 200 feet east of Medical Center Drive	1,181.79	20	280–740 800–890	0.08	270 800	415	900
EW-112PA		1,181.79	4	300–320	0.02			320
EW-112PB		1,181.79	4	660–680	0.02			680

bgs = below ground surface
ft = feet
msl = mean sea level
NA = not applicable

Well Construction Details. Table 2-2 presents the well construction details for the five extraction wells and associated piezometers. Well construction logs are included in Attachment A. A discussion of well construction details for each location follows. Screened intervals for all new extraction wells were selected based on the location of permeable zones and the understanding of vertical distribution of contaminants at the time of installation. Gravel-feed tubes and camera tubes were installed in some extractions wells to replenish filter pack in the annulus, if necessary, and to allow a camera, or other well inspection equipment, to be inserted to observe the condition of the well. Gravel-feed tubes and camera tubes are open-ended, 4-inch inside diameter (ID) low-carbon steel casings.

EW-108. Completed in May 2001, EW-108 was constructed with 20-inch ID, Roscoe Moss Full Flow louvered steel screens, with 0.07-inch openings, from 510 to 590 and 670 to 1,000 feet bgs. Above and between the screened sections, the well consists of 20-inch ID, low-carbon steel casing. A 10-foot steel sump with a bottom plate was installed below the deeper screen. Two piezometers (EW-108PA and EW-108PB) and two gravel-feed tubes were installed in the EW-108 borehole. The piezometers were constructed with 20 feet of 2-inch ID, continuous wire wrap, stainless steel screens with 0.02-inch openings attached to 4-inch ID, low-carbon steel casings.

Subsequent to construction, an attempt was made by SBMWD to perforate a portion of the upper casing. Information obtained from a video log of the well on January 5, 2005, indicates that eight perforations per row, at a vertical spacing of approximately 6 inches were attempted from approximately 311 to 422 feet bgs. Evidence from the video log and aquifer test data suggest that this did not provide significant access to this upper zone. Furthermore, spinner test data indicates that no (or minimal) flow into the extraction well is produced from this area (URS, 2005).

EW-109. Completed in October 2003, EW-109 was constructed with 20-inch ID, Roscoe Moss Full Flow louvered steel screens, with 0.08-inch openings, from 260 to 330, 420 to 500, 550 to 610, and 710 to 840 feet bgs. Above and between the screened sections, the well consists of 20-inch ID, low-carbon steel casing. A 10-foot steel sump with a bottom plate was installed below the deepest screen.

Three piezometers (EW-109PZA, EW-109PZB, and EW-109PZC), three gravel-feed tubes, and a camera tube were installed in the same borehole as EW-109. The piezometers were constructed with 20 feet of 4-inch ID, continuous wire wrap, stainless steel screens with 0.02-inch openings attached to 4-inch ID, low-carbon steel casings.

EW-110. Completed in April 2004, EW-110 was constructed with 20-inch ID, Roscoe Moss Full Flow louvered steel screens, with 0.08-inch openings, from 225 to 270, 305 to 650, 715 to 855 feet bgs. Above and between the screened sections, the well consists of 20-inch ID, low-carbon steel casing. A 10-foot steel sump with a bottom plate was installed below the deepest screen.

One piezometer (EW-110PZE), two gravel-feed tubes, and a camera tube were installed in the EW-110 borehole. The piezometer was constructed with 20 feet of 4-inch ID, continuous wire wrap, stainless steel screen with 0.02-inch openings attached to 4-inch ID, low-carbon steel casing.

Four piezometers (EW-110PZA, EW-110PZB, EW-110PZC, and EW-110PZD) were installed in a separate borehole approximately 20 feet northwest of EW-110. The piezometers were constructed with 20 feet of 4-inch ID, continuous wire wrap, stainless steel screens with 0.02-inch openings attached to 4-inch ID, low-carbon steel casings.

EW-111. Completed in March 2004, EW-111 was constructed with 20-inch ID, Roscoe Moss Full Flow louvered steel screens, with 0.08-inch openings, from 235 to 265, 305 to 665, 765 to 1,250 feet bgs. Above and between the screened sections, the well consists of 20-inch ID, low-carbon steel casing. A 10-foot steel sump with a bottom plate was installed below the deepest screen.

One piezometer (EW-111PZD), two gravel-feed tubes, and a camera tube were installed in the EW-110 borehole. The piezometer was constructed with 20 feet of 4-inch ID, continuous wire wrap, stainless steel screen with 0.02-inch openings attached to 4-inch ID low-carbon steel casing.

Three piezometers (EW-111PZA, EW-111PZB, and EW-111PZC) were installed in a separate borehole, approximately 20 feet northwest of EW-111. The piezometers were constructed with 20 feet of 4-inch ID, continuous wire wrap, stainless steel screens with 0.02-inch openings attached to 4-inch ID, low-carbon steel casings.

EW-112. Completed in March 2001, EW-112 was constructed with 20-inch ID, Roscoe Moss Full Flow louvered steel screens, with 0.08-inch openings, from 280 to 740 and 800 to 890 feet bgs. Above and between the screened sections, the well consists of 20-inch ID, low-carbon steel casing. A 10-foot steel sump with a bottom plate was installed below the deeper screen. The sump and the deeper screened interval were constructed, then backfilled with gravel pack and plugged. Subsequently, the plug and the gravel pack were removed by SBMWD, allowing for access to this water-bearing zone. Spinner tests performed in October 2005, after the backfill was removed, indicated that this area produced approximately 5% of the total well yield (URS, 2005).

Two piezometers (EW-112PA and EW-112PB) and two gravel-feed tubes were installed in the EW-112 borehole. The piezometers were constructed with 20 feet of 2-inch ID, continuous wire wrap, stainless steel screens with 0.02-inch openings attached to 4-inch ID, low-carbon steel casings.

2.1.3 Extraction Well Development

After construction, each well was developed by a combination of swabbing, air-lift pumping, and pumping by Layne Christensen Company, contracted by SBMWD. Data collected by SBMWD during development is provided as Attachment C. Due to the problem encountered during the drilling of EW-109 (equipment breakdown and poor solids control of the drilling fluid) excessive development was required. After the removal of the backfill material from EW-112, the backfilled portion of the extraction well was not re-developed.

2.2 MONITORING WELLS

2.2.1 Monitoring Well Locations

Five triple-completion groundwater monitoring wells (MW-135 through MW-139) were placed in an east-west line, south of Baseline Street, in the southern portion of the Muscoy Plume OU. These wells were installed on available properties at mid-point locations downgradient from the Muscoy Plume OU extraction wells. One triple-completion monitoring well (MW-140) was placed in the north-central part of the Muscoy OU. This well was installed to fill the data gap created by the vandalism that rendered the "Colima well" (a Municipal well at Colima Ave. and Dunn Ave.) unuseable. All of the monitoring wells were installed to provide locations to collect groundwater samples and measure water levels to monitor the progress and performance of the Muscoy Plume OU extraction wells.

The locations of MW-135 through MW-139 were based on the following requirements:

- Areas downgradient of anticipated Muscoy Plume OU extraction wells;
- Areas where municipal pumping may have critical influence on extraction well network performance;
- Municipal or private property with sufficient square footage for well installation activities; or
- Areas that minimize disruption of municipal and private activities.

The following criteria were used for screen placement at MW-135 through MW-139:

- The screens were placed opposite borehole sections that correlate vertically with anticipated completion intervals of the extraction wells.
- The screens were placed in permeable lithologic units as estimated from logging borehole cuttings and low electrical resistivity measurements from geophysical logs.
- The deepest completions were placed to monitor the deeper portion of the aquifer that potentially could be affected by deep extraction from the Antil Well Field located south of the Muscoy Plume OU extraction/monitoring well network.

The location of MW-140 was selected to fill the data gap formerly present in the northern Muscoy OU and as a location that would provide valuable groundwater elevation data upgradient of the Muscoy OU extraction well network. The screens for MW-140 were placed in permeable lithologic units as estimated from logging borehole cuttings and low electrical resistivity measurements from geophysical logs.

2.2.2 Monitoring Well Construction

Drilling Methods. The five downgradient triple-completion monitoring wells (MW-135 through MW-139) were installed between February and April 2002 and the upgradient monitoring well (MW-140) was installed in March 2006. The wells were installed using reverse-circulation mud rotary techniques. Borehole drilling and well installation for MW-135 through MW-139 were performed by Water Development Co. and by Best Drilling and Pump for MW-140. The drilling subcontractors were retained by URS.

Temporary conductor casings were installed at each monitoring well location to approximately 60 feet bgs. Conductor casings were used to stabilize subsurface formation material and to assist in creating a closed drilling fluid circulation system, reducing the possibility of drilling fluid loss into poorly consolidated or unconsolidated formation material at shallow depths.

Boreholes were initially drilled with a 10.5-inch diameter bit to total depth. In order to accommodate the wells, the boreholes were subsequently reamed to a diameter of 14.5 inches to approximately 10 feet deeper than the bottom of the deepest well completion (Table 2-1).

A URS geologist logged drill cuttings as each borehole was drilled. Recorded information includes grain size and shape, grading, mineralogy, United Soil Classification System designation, and other observations. Lithologic samples were collected from the discharge line at approximately 20-foot intervals. Lithologic logs for all locations are presented in Attachment A.

A suite of geophysical logs was collected from each borehole by Pacific Surveys. These logs are presented

in Attachment A.

Well Construction Details. Table 2-3 presents the well construction details for the six triple-completion monitoring wells. Well construction logs are included in Attachment A.

All of the downgradient monitoring wells (MW-135 through MW-139), with the exception of MW-139C (see below), were constructed with 20 feet of 4-inch ID, continuous wire wrap, stainless steel screens with 0.02-inch openings. Immediately above each screen, a 10-foot section of 4-inch ID, stainless steel casing with a Di-electric coupler was installed. Above this, the wells consist of 4-inch ID, low-carbon steel casing.

TABLE 2-3

Monitoring Well Construction Details

Well	Location	Casing Elevation (ft above msl)	Casing/ Screen Diameter (inches)	Screened Interval (ft bgs)	Screen Slot Size (inches)	Borehole Depth (bgs)	Total Well Depth (feet)
MW-135A	Southern side of Orange Street, just east of southbound entrance to Interstate 215	1,111.28	4	360–380	0.02	880	380
MW-135B		1,111.28	4	620–640	0.02		640
MW-135C		1,111.30	4	850–870	0.02		870
MW-136A	Northern side of 11th Street, between Perris Street and L Street	1,121.67	4	420–440	0.02	930	440
MW-136B		1,121.63	4	500–520	0.02		520
MW-136C		1,121.61	4	730–750	0.02		750
MW-137A	Eastern side of Harrington Avenue, approximately 50 feet south of Baseline Street	1,144.05	4	330–350	0.02	912	350
MW-137B		1,144.10	4	520–540	0.02		540
MW-137C		1,144.07	4	790–810	0.02		810
MW-138A	Eastern side of Western Avenue, approximately 50 feet south of Baseline Street	1,156.87	4	320–340	0.02	1,000	340
MW-138B		1,156.92	4	550–570	0.02		570
MW-138C		1,156.99	4	960–980	0.02		980
MW-139A	Western side of Wilson Street, approximately 100 feet south of Baseline Street	1,168.76	4	360–380	0.02	855	380
MW-139B		1,168.71	4	540–560	0.02		560
MW-139C		1,168.85	3	795–810	0.01		810
MW-140A	Southeast corner of California Avenue and Darby Avenue.	1,304.41	4	300–400	0.02	865	400
MW-140B		1,304.39	4	530–560	0.02		560
MW-140C		1,304.39	4	690–720	0.02		720

bgs = below ground surface
ft = feet
msl = mean sea level

During installation, the MW-139C screen was parted so a 3-inch ID liner was constructed inside the existing 4-inch casing. With the exception of the 3-inch well diameter and the 15-foot, continuous wire wrap, stainless steel screen with 0.01-inch openings, the well materials used match the other monitoring wells. The 0.01-inch screen opening size was utilized because the screened interval is set in natural fill as opposed to filter-pack sand. A neat cement seal was installed between the 4-inch and 3-inch ID, low-carbon steel casings.

MW-140A was constructed with 100 feet of 4-inch ID, continuous wire wrap, stainless steel screen with 0.02-inch openings. MW-140Band MW-140C were constructed with 30 feet of 4-inch ID, continuous wire wrap, stainless steel screens with 0.02-inch openings. Immediately above each screen, a 10-foot section of 4-inch ID, stainless steel casing with a Di-electric coupler was installed. Above this, the wells consist of 4-inch ID, low-carbon steel casing.

All six locations were completed with a 16-inch stovepipe inside a flush-mounted Christy box.

2.2.3 Monitoring Well Development

After construction, each well was developed by swabbing and air-lift pumping and surging until turbidity measured less than 25 nephelometric turbidity units (NTUs). After allowing the well to recover from initial development, each well was purged with an electric submersible pump until turbidity was maintained at 20 NTUs or less. Table 2-4 summarizes the gallons of water removed during development and the final NTU readings for each well.

TABLE 2-4

Monitoring Well Development Summary

Well	Gallons Removed	Final NTU
MW-135A	974	0
MW-135B	3,148	3.7
MW-135C	6,009	18.85
MW-136A	1,575	0
MW-136B	3,715	16.44
MW-136C	2,145	5.3
MW-137A	675	0.7
MW-137B	1,038	0.08
MW-137C	1,173	2.14
MW-138A	2,190	15.9
MW-138B	2,688	13.92
MW-138C	3,245	3.44
MW-139A	2,154	3.6
MW-139B	2,450	15.59
MW-139C	4,090	0.49
MW-140A	5,772	17
MW-140B	12,073	19
MW-140C	2,741	17